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Common-Sense Pest Control – Least-Toxic Solutions For Your Home, Garden, Pets and Community, 1991 (so technically considered out-of-date):

- Integrated Pest Management (IPM) asks if the damage is tolerable and determines tolerable damage or injury levels caused by pests.
- Gives criteria for selecting a treatment strategy
- Highlights the beneficial organisms

Pesticides - Chapter 6 – Choosing the Right Chemical and Microbial Tools:

- background information on the composition, application and impact of various pesticides, including the novel botanical and microbial materials.

- Seeks to provide enough information to enable you to select the safest, most effective material and apply it in a manner that protects both you and the general environment.

- Gives a brief history of the use of chemicals against pests – before WWII pesticides were mostly inorganic materials (sulphur, lead, copper, arsenic, boron and mercury) as well as botanical (plant-derived) compounds such as nicotine, pyrethrum, derris, rotenone, ryania and sabadilla.

- Then came DDT. It worked 'so well' that research slowed as well as development of other, less-toxic methods of pest control, particularly biological controls. Even the gradual accumulation of evidence that the entire planet was becoming contaminated with these materials… failed to impress upon many responsible people the real threat posed by this type of pollution.

- A broad-spectrum approach is harmful to beneficial insects and microbes and can contaminate groundwater and other resources. Better to take a highly selective approach to kill only certain groups of pests… while minimizing the risk to human health through contamination.

- The classification of chemicals as pesticides is complicated but the word "pesticide" is an umbrella term for all the sub-categories of materials used to suppress pests. These include insecticides, herbicides, fungicides and rodenticides.

- If a product is sold as a pesticide, it must be registered at the federal level by the Environmental Protection Agency and must carry labels describing the proper dosage and frequency of application for the control of specific pests. Also a list of active ingredients, the relative toxicity to mammals and other information including cautions regarding hazards to humans and the environment. The adequacy of the regulations are controversial.

- How well/closely are these products and their details monitored in Bermuda?

- Naming of compounds in pesticides is often difficult as each has at least 2 or 3 names.

- The generic name (eg. carbaryl) can be searched to obtain information about its toxicity and effectiveness. There is also the chemical name (eg. 1-naphthalenyl methylcarbamate), which describes the molecule… and sometimes there is more than one chemical name for a compound, depending on the conventions used to describe the molecule. Finally, there is the trade or brand name, which is what you ask for in the store. (This approach of having all these names seems highly dangerous given the importance and risks associated with many of these chemicals!)

- **It is also important to understand the way the pesticide affects the pest… <u>the mode of action</u> and <u>formulation</u>**.

- Least-toxic pesticides operate physically or mechanically, causing the pest to dehydrate and die. Others have a biochemical mode of action, disrupting enzymes, hormones, nervous transmission or other biophysical processes of the target pest. The total impact on the organism and the environment of a pesticide with a biochemical mode of action is difficult to predict and unanticipated side effects are more often encountered with this type of pesticide.

- The formulation of a pesticide refers to the mixture of its active ingredient with other ingredients that affect the active ingredient's (i) solubility, (ii) ability to stick to vegetation or insect bodies or (iii) other functions.

- Substances other than the active ingredient are referred to as adjuvants. An example of an adjuvant is a surfactant, which enhances the coverage of a sprayed-on pesticide by allowing greater pesticide contact. These adjuvants are called "inert substances" which can often be a misnomer since they generally are not inert and, in some cases are more toxic than the active ingredient itself. **Of real concern is that only the active ingredient is tested by the registration agencies, not the complete formulation of a pesticide, which is what people and other non-target organisms are exposed to!**

- Pesticides are classified by (i) their target pest group (eg. herbicides for plants, fungicides for fungi, miticide for mites), (ii) formulation (baits, dusts, fumigants, granules, sprays), (iii) chemical category (inorganic, organic) and/or function (eg. attractant, repellent, insect growth regulator).

- Insecticides can also be classified according to the stage in which they are effective… egg, larva (caterpiller, worm, grub or nymph), pupa (cocoon)

and adult. Thus, an ovicide attacks eggs; a larvicide attacks the young and an adulticide attacks mature individuals.

- Another major point about pesticide classification is that within the major categories (insecticides, herbicides, fungicides, etc.) there are often subgroups peculiar to that group. For example, herbicides are frequently classified according to when they are applied in the life cycle of weeds. Pre-emergent herbicides are applied before the weed germinates; post-emergent after the weed growth is underway. Additionally, a 'selective' herbicide is intended to kill certain weeds but leave desirable plants whereas a non-selective herbicide is toxic to most plant material it encounters.

- Herbicides classified according to their mode of activity of which there are 3: contact, translocated or residual.

- Contact herbicides injure of kill plants on contact with their foliate. They kill only that part of the plant with which they come into contact (also called "chemical mowers").

- Translocated herbicides move through the entire plant system carried by water and food streams, to the plant's active growth centres, which they damage or destroy. They can be applied to the soil around the plant or to the plant's foliage and are usually selective in the range of plants they affect.

- Soil residual herbicides are those that remain active in the soil for relatively long periods, depending on the dosage. To be effective, they must be sprayed directly on emerging plant shoots or washed into the soil where they are taken up by the roots and carried to the leaves. They are relatively ineffective when sprayed on mature foliage.

- Toxicity- to humans:

    - There are two general kinds of toxicity: acute and chronic. A given dose of a poison is said to have acute toxicity if it affects human health adversely after a relatively short term of exposure. It has chronic toxicity if it has an adverse impact after long-term exposure (which can range from days to years).
    - The most common method of measuring the acute toxicity of a pesticide is by giving test animals (rats, dogs, chickens, rabbits, monkeys, pheasants, ducks) known doses of the poison and observing the results. Humans, however, may not react to the poison exactly as other animals do.
    - Acute toxicity can also be measured by the amount of pesticide vapor or dust in a given volume of air or the amount diluted in waterways that will cause the death of any specific proportion of a test-animal population.

- Cautions on the labels. By law, a signal word must be included on every pesticide label to give the user some indication of the acute toxicity of the material: caution indicates materials that are least-toxic (Category III or IV); warning (nothing said about this); or danger which indicates they are most toxic and are generally restricted to use by professional pest control operators.
- Routes of exposure: Oral, dermal (on the skin) interdermal (in the skin), interocular (in the eye) internasal (in the nose) and respiratory (in the lungs).
- The respiratory route of entry is usually the most toxic of all because pesticides are absorbed most rapidly through the lungs and distributed throughout the body in the bloodstream, causing all organs and tissues to be exposed within minutes after inhalation. However, studies of lung exposure to pesticides have been relatively few to date with little or no comparative data available.
- The eye is also highly susceptible to the absorption of pesticides, which is why it is important to wear goggles whenever pesticides are applied. Other areas that are highly susceptible are: the scrotum, the armpit, ear canal and face.
- Toxicity ratings don't indicate chronic or long-term effects.
- Chronic effects may be carcinogenic (causing cancer), mutagenic (causing genetic changes) or teratogenic (causing birth defects).
- There is substantial variation in the impact of a toxic substance from individual to individual and from one developmental stage to another. For example, children, the elderly, pregnant women and the sick are more vulnerable than a younger but mature 150 lb man in the peak of health.
- Additional, lesser symptoms like rashes, sleepiness or restlessness in sensitive individuals are always attributed to pesticide exposure.
- Data on chronic toxicity (effects of exposure over a long period) is woefully inadequate or completely missing for most of the more than 600 registered active ingredients in pesticide products (and inert ingredients aren't required to be tested). 90% - 99% of the volume of the material is inert and so the fact that inert ingredients are not on the labeled nor tested is of grave concern. Some of the inert ingredients are more toxic than the active ingredient eg. the surfactant in the herbicide Roundup is more toxic than its active ingredient, glyphosate).
- Another potential danger is *synergism,* which occurs when one compound enhances the effect of another many times beyond what would be experienced if either were encountered alone. This is why, for example, alcohol should not be combined with certain drugs. It is very difficult to determine safe levels when taking into account that we are exposed to multiple sources of toxic materials.
- There is a growing number of "chemically sensitive" individuals who are suffering damage to their immune systems from chronic exposure to synthetic compounds such as pesticides.

    - Manufacturers are now required to provide a material safety data sheet (MSDS) for each pesticide they produce to describe the chemical characteristics of the active and other hazardous ingredients etc. These data sheets should be available from anyone selling or using the material.

- Toxicity in the environment (biomagnifications):
    - The application of most pesticides often results in only a small amount of the poison actually reaching the target pest. Most of the material lands in adjacent areas, meaning that it falls on non-target organisms, plants, other animals and the soil.
    - All kinds of undesired side effects can result. For example, fungicides used against a plant disease may fall on and become incorporated into the soil, inhibiting the growth of the beneficial fungi called *mycorrhizae* that are important in helping the plant to obtain nutrients.
    - Some pesticides accumulate in food chains and become concentrated in the bodies of the organisms that eat those plants or animals. For example, organisms such as earthworms that are low on the food chain may eat many fallen leaves. Even though each leaf holds only a small amount of pesticide residue, the pesticide is concentrated in the earthworm's body because of the number of leaves it consumes. This concentrated dose is then passed on to the earthworm's predators, such as birds and because a single bird eats many earthworms, the pesticide reaches even higher concentrations in the bird's body. Finally, at the top of that food chain, bird predators such as cats may ingest such high concentrations of poison that they become sick or suffer in other ways.
    - **Residue, Resurgence, Resistance and Secondary Pest Outbreaks**: lists the main problems associated with pesticide use.
        - **Biomagnification is one aspect of the residue problem, but residues can also be a more direct problem**. Pesticides sprayed inside a house could fall on dishes and other surfaces or mix with the air we breathe. Outside they often get into the groundwater or other waterways. From there they can contaminate wells or have undesired effects on aquatic life. In 1988 the EPA found the groundwater in 38 US states to be contaminated by 74 pesticides. It is primarily the residue problem that inspired Rachel Carson's book Silent Spring about the devastating effects due to the use of DDT.
        - **Resurgence, Resistance and the secondary Pest Outbreak are of greater direct concern to the pest manager**.
        - **Resurgence occurs when the predators that would naturally control the pests are temporarily removed or drastically reduced in number by the use of the pesticide resulting in a resurgence of the pest with**

fewer predators to help to naturally keep it under control.

- **When the gardener sees this resurgence of the pest he/she wants to spray again or worse, more exacerbating the problem**. Populations of predators often take longer to build back up than the pest and also, the pesticide used may be even more toxic to the predator than to the pest. This is true, for example of carbaryl (Sevin), which is still popular with home gardeners and pest control professionals even though it is toxic to honeybees.
- **Resistance can potentially cause more problems than residue or resurgence**. Each time a pesticide is applied, some of the pests that survive to produce the next generation develop a means of avoiding or detoxifying the poison. This is very different from immunity where the body develops antibodies to a disease organism. The resistance we are referring to is one of forced genetic selection. By creating a situation where only those organisms that can tolerate a pesticide survive and reproduce, it gradually becomes harder to reduce pest numbers through application of the poison. In response, many people increase the frequency of treatment and/or the strength of the dose.
- **In agriculture, resistance to pesticides has become a matter of world-wide concern**. Switching to a new compound may help but the success may be short-lived due to the phenomenon known as cross-resistance. Once a pest has developed resistance to one class of chemicals, it usually develops resistance to others and often in a short time. The implications of this phenomenon for the field of public health are particularly important.
- **More than 600 pest insects, weeds and plant pathogens are now resistant to one or more pesticides**. For this reason, chemical tools must always be regarded as temporary solutions.